Journal of Environmental Chemical Engineering 4 (2016) 1780–1796

Contents lists available at ScienceDirect

Journal of Environmental Chemical Engineering

journal homepage: www.elsevier.com/locate/jece

Adsorption and Kinetic studies of *Adhatoda vasica* natural dye onto woolen yarn with evaluations of Colorimetric and Fluorescence Characteristics

Luqman Jameel Rather[a], Shahid-ul-Islam[a], Mohd Ali Khan[b], Faqeer Mohammad[a,*]

[a] Department of Chemistry, Jamia Millia Islamia (A Central University), New Delhi 110025, India
[b] Department of Post Harvest Engineering and Technology, Faculty of Agricultural Sciences, A.M.U, Aligarh 202002, U.P., India

ARTICLE INFO

Article history:
Received 16 December 2015
Received in revised form 11 February 2016
Accepted 2 March 2016
Available online 4 March 2016

Keywords:
Natural dye
Adhatoda vasica
Adsorption
Kinetics
Colorimetric properties

ABSTRACT

In the present investigation adsorption studies, colorimetric, and emission characteristics of *Adhatoda vasica* natural dye onto woolen yarn were investigated. Assessment of the effect of pH on dye adsorption showed an increase in adsorption capacity with decreasing pH, with maximum adsorption at pH 3. Pseudo-first order, Pseudo-second order, Elvoich, and Intraparticle diffusion equations were employed to investigate adsorption rates. Pseudo-second order model provided best fit to the experimental data with activation energy of 69.039 kJ mol^{-1} indicating chemisorption. The equilibrium adsorption data were fitted to Langmuir, Freundlich, Redlich-Peterson, and Hill isotherm models. Redlich-Peterson and Hill isotherm models agreed well with the experimental data having high regression coefficients and least standard deviations for dyeing temperatures of 50, 70 and 90 °C with dye concentration varying from 0.5–20% (o.w.f). A comparative adsorption investigation on silk fiber was presented to understand the better efficiency of woolen yarn. Colorimetric properties and fluorescence characteristics of dyed woolen yarn mordanted with metal salts were generally dependent on chemical nature of mordants and wool-mordant-dye complex forming ability.

1. Introduction

Natural dyes have become part and parcel of human lives since prehistoric times. There is great possibility of generation of income through sustainable harvest and sale of these plants besides offering rich and varied source of dyestuffs. People used to dye carpet, rug, and cloth by using roots, stems, barks, berries, leaves and flower extracts of various dye plants [1–3]. Since last few decades, there has been a growing interest over the application of natural dyes on textile materials all over the globe, possibly because of increasing awareness of their bio-compatibility, bio-degradability, renewability, and low allergic reactions [4–6]. In the present context of eco-preservation and eco-friendliness, natural dyes have acquired tremendous commercial potential in response to synthetic dyes due to the synthesis, processing and release of hazardous by-products into the environment [7–9]. Although, vegetable dyes cannot replace synthetic dyes, they have several advantages over synthetic dyes with regard to health, safety, and ecology [2,10,11]. Natural dyes also exhibit other preferable properties, such as insect repellent, deodorizing, flame retardant, UV protection, fluorescence, and antimicrobial activity [12–19].

Adhatoda vasica (Fig. 1), a well-known plant drug in Ayurvedic and Unani medicine, found throughout Indian peninsula up to an altitude of 1300 m, is used for treatment of various diseases and disorders, particularly for respiratory tract ailments. The most studied and the main chemical components of *A. vasica* reported are vasicine and vasicinone, confirmed by HPLC and other spectral analysis [20–23], molecular structures are given in Fig. 2. The major alkaloid of this plant, vasicine has been found biologically active [24–27] but very little information is available on its dyeing properties [28], and hence can be explored as an effective and sustainable natural dye for coloration and surface finishing of textile materials to overcome the growing demands of textile industry. Recently, lot of investigations have been undertaken on dyeing and functional finishing of textile materials along with the evaluations of thermodynamics and kinetic parameters [29–34].

Fundamental studies on adsorption kinetics and thermodynamics of dyeing processes are important for understanding the dyeing mechanisms and improving dyeing performance of natural dyes on various textile materials. An adsorption isotherm curve describes phenomenon of retention of substances from aqueous

* Corresponding author.
E-mail addresses: makamu4@yahoo.co.in (M.A. Khan), faqeermohammad@rediffmail.com (F. Mohammad).

http://dx.doi.org/10.1016/j.jece.2016.03.003
2213-3437/

Fig. 1. Image of *Adhatoda vasica.*

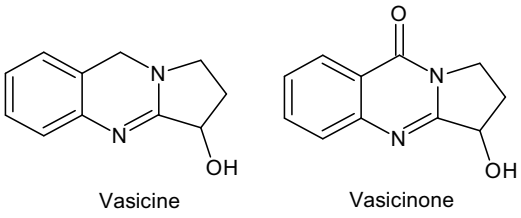

Fig. 2. Chemical structures of components of *A. vasica.*

media onto solid-phase at constant temperature and pH [35,36]. A mathematical correlation constitutes an important step, expressed graphically as a function of solid-phase and residual concentrations, for modeling analysis, operational design and applicable practice of adsorption systems [37].

For this reason, present research deals with the application of *A. vasica* natural dye onto woolen yarn with preliminary emphasis on kinetic and thermodynamic adsorption aspects. Also build-up properties of *A. vasica* was carried out using three metal salts (Alum, ferrous sulfate and stannous chloride) and emission spectral adsorption characteristics of woolen yarn were investigated and compared with that of the blank dyed samples.

2. Experimental

2.1. Materials and chemicals

100% pure New Zealand semi worsted woolen yarn (60 counts) for assessment of colorimetric properties and color fastness tests was procured from MAMB Woolens Ltd. Bhadohi, S R Nagar

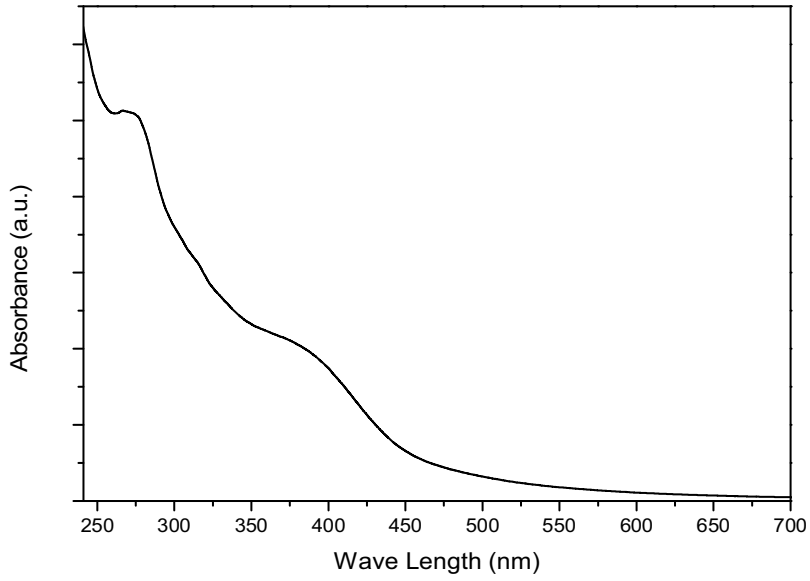

Fig. 3. Absorbance spectra of *A. vasica* dye solution at pH 7.